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BOTTOM AND PHYTOPHILOUS MACROFAUNA OF THE RIVER CZERNIEJÓWKA, TAKING INTO ACCOUNT BIOTIC AND ABIOTIC FACTORS AND HUMAN IMPACT

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Summary. The bottom and phytophilous fauna of the river Czerniejówka were studied in two types of landscape – rural and urban. In the rural area the river had retained its natural character, while in the urban area it had been greatly affected by human impact (straightened river bed, altered structure of the banks, concrete bottom, polluted water). A total of 5.578 macroinvertebrate specimens were caught, belonging to 42 taxa of varying systematic positions. Dominating the material collected were *Gammarus* sp. (41.2%), Chironomidae larvae (15.4%), and Hydrachnidia (10.7 %). The biological diversity index ranged from 1.20 to 3.66. The taxonomic composition and frequency of occurrence of the fauna were mainly determined by biotic factors (e.g. abundance of aquatic vegetation) and abiotic factors (e.g. water current and type of bottom sediment), whereas the type of landscape (rural and urban), human impact, and the physical and chemical properties of the water did not strongly influence the fauna of the river.

Key words: macroinvertebrates, biotic factors, abiotic factors, human impact, biological diversity

INTRODUCTION

The aquatic invertebrate fauna of the Lublin region has been unevenly researched, in terms of both particular parts of the region and types of water body. Research usually concerns protected areas of the region (national parks, landscape parks, nature reserves), and in these areas the studies mainly concentrate on standing water bodies. There is still very little data on the invertebrate fauna of running water bodies of the Lublin region, including the close vicinity of Lublin. Studies thus far conducted on small rivers of the Lublin region, including the Bystra, the Ciemięga, the Czechówka, the Czerniejówka, the Kosarzewka, the Krężniczanka and the Minina, are in typescript form [e.g. Stryjecki 1992, Cieślak 2006, Gorzel

2008, Więch 2008], not in the form of published data. Documentation and publication of data on the macrofauna of the region's watercourses is particularly advisable as they are strongly influenced by human activity (straightening of river beds, changes in bank and bottom structure, and above all, increasing pollution), which has a detrimental effect on aquatic invertebrate communities inhabiting these rivers.

The aim of this study was to determine the composition of the bottom and phytophilous fauna of the river Czerniejówka, both outside of Lublin and within the city and to determine the effects of biotic and abiotic factors and of anthropogenic activity on the fauna of the river.

STUDY SITES AND METHODS

Samples were taken at six study sites – three outside of Lublin and three within the administrative limits of the city.

Study site 1 – in Jabłonna. A natural river bed with meanders. On the banks were meadows or small clusters of trees. The river was about 3–3.5 m wide, and its depth ranged from 0.1 m in the shallows to 0.5 m in the deepest waters. The sediments in the lotic zone were sandy. Near the banks there were small areas of water with muddy bottoms and very slow current. Aquatic vegetation was very sparse, with a few macrophytes occurring only in the lentic zone. Water flow was rapid (0.45 m/s).

Study site 2 – in Czerniejów. A natural stretch of the river, with meanders. Variable width averaging about 4 m. Depth varied significantly, from 0.2 m to 0.6 m. The lotic zone was dominant, with a sandy bottom devoid of vegetation. In some places the bottom consisted of sand and pebbles. Near the banks there were small, still areas of water with muddy bottoms. The current was fast (0.43 m/s); the flow was laminar, and in some places turbulent. There were scattered residential buildings on the banks.

Study site 3 – in Mętów. The river had retained its natural character, with meanders, no dikes, a sandy bottom on most of the cross profile and a muddy bottom by the banks. The width ranged from 4 to 6 m; the depth varied from 0.3 m to 0.6 m. A mosaic of many habitats occurred at this site: in the lotic zone algae grew abundantly on stones during the vegetative period, and there were abundant patches of *Veronica beccabunga* L. as well. The vegetation on the banks consisted mainly of *Phalaris arundinacea* L. and *Glyceria aquatica* (L.) Wahlenb. Water flow was rapid (0.55 m/s). There was little human impact (scattered buildings in the valley).

Study site 4 – in Lublin, ul. Głuska. The river here takes the form of a straightened ditch with dikes. It is about 4 m wide and 0.5–0.6 m deep. Sediments were of silt or sand and silt. The dominant vegetation was *Elodea canadensis* Michx. (a. Rich), which grew over the entire cross section of the river. *Potamogeton pectinatus* L. was also quite common. *Veronica beccabunga* and *Ceratophyllum* sp. were noted as well. Water flow was slow (0.37 m/s). There was considerable human impact: dense development in the valley, a straightened river bed with dikes, polluted water, banks lined with concrete revetments, a concrete bottom.

Study site 5 – in Lublin, ul. Mickiewicza. The river here was quasi-natural, with slight meanders and no concrete revetments or bottom. About 4–5 m wide, up to 0.7 m. deep. The bottom consisted of sand and silt. Dense semi-aquatic vegetation grew by the banks. In the central part of the river macrophytes were abundant: *Elodea canadensis*, which grew over the entire cross section of the river, as well as *Potamogeton pectinatus*, *Veronica beccabunga* and *Ceratophyllum* sp. *Lemna minor* L. and *Myosotis palustris* (L.) L. em. Rchb. were noted by the banks. Human impact could be seen in the various objects polluting the river, dikes, straightened stretches of the river bed, and garden plots near the river banks.

Study site 6 – in Lublin, ul. Fabryczna. A stretch of the river in the centre of the city, near the estuary, lacking in habitat variation (microhabitats). It was about 6 m. wide and 0.4–0.6 m deep. The bottom consisted of silt or silt and sand. Isolated specimens of *Potamogeton pectinatus* and *Veronica beccabunga* grew in midstream. Flooded semi-aquatic vegetation grew near the shore. Human impact could be seen in the straightened river bed, dikes, concrete bank revetments reaching the bottom, dirty sand, gravel, stones and large amounts of rubbish on the bottom.

Samples were taken using a hand net which had a square frame with 0.25 m sides and 0.25 mm apertures in the net. Material was collected once a month from April to October 2009. At each site samples were taken on a stretch of the river about 10 metres long, which given the 0.25 m width of the net frame yielded a total sampling area of 2.5 m^2. During the study the basic physical and chemical parameters of the water were measured (temperature, pH, electrolytic conductivity, dissolved oxygen, oxygen saturation – detailed data are available from the author). Current velocity was also determined (by the floating object method). Taxonomic diversity was calculated using the Shannon-Wiener formula (base 2 logarithm).

RESULTS

At the six study sites in the Czerniejówka river, 5,578 macroinvertebrate specimens were collected, belonging to 42 taxa of varying systematic position (species, genus, family, order, phylum) – Table 1. Dominant in the material collected were *Gammarus* sp. (41.2%), Chironomidae larvae (15.4%), and Hydrachnidia (10.7%).

Considerable differences in domination structure were noted between the various study sites. At site 1 (Czerniejówka in Jabłonna) the dominant group (dominance > 5%) consisted of only two taxa – *Gammarus* sp. (79.9%) and Chironomidae larvae (9.1%). The remaining 16 taxa caught at this site comprised 11.0% of the fauna collected there. At site 2 (Czerniejówka in Czerniejów) 24 taxa were noted, of which the dominants were Chironomidae (39.2%), Hydrachnidia (23.5%), *Gammarus* sp. (13.3%) and *Sphaerium* sp. (8.3%). At site 3 (Czerniejówka in Mętów) 25 taxa were found, with a greater than 5% share of *Gammarus* sp. (51.3%), Hydrachnidia (6.8%), Chironomidae (6.4%), Simuliidae (5.3%), *Hydropsyche* sp. (5.1%) and *Pisidium* sp. (5.1%). At site 4 (in Lublin, ul. Głuska) 28 taxa were noted; the dominants were *Gammarus* sp. (27.4%), eruciform larvae of Trichoptera non det. (11.3%), *Sphaerium* sp. (10.0%), Hydrachnidia (9.3%) and *Hydropsyche* sp. (8.1%). At site 5 (in Lublin, ul. Mickiewicza) 29 taxa were caught – the most of all the study sites (Tab. 1).

Table 1. List of invertebrates caught in the Czerniejówka river (2009)

Taxon	1*	2	3	4	5	6	Total
Dugesia sp. (?)		1					1
OLIGOCHAETA:							
Oligochaeta non det.		3	3	7	33	83	129
Lumbriculidae	1				4	4	9
HIRUDINEA:							
Erpobdellidae	3	10	34	30	28	82	187
Glossiphonia complanata (L.)		3	6	1	2	1	13
Helobdella stagnalis (L.)			2	2	1	4	9
CRUSTACEA:							
Asellus aquaticus L.	2	32	26	29	55	9	153
Gammarus sp.	1095	161	676	177	190	1	2300
ARACHNIDA:							
Hydrachnidia	7	285	90	60	108	47	597
INSECTA:							
Ephemeroptera:							
Ephemeroptera non det.	10	20	29	6	16		81
Ephemera sp.		1	2	7			10
Odonata:							
Coenagrionidae				5	6	3	14
Calopteryx sp.	1			29	4	4	38
Heteroptera:							
Corixidae			10	15	3	32	60
Notonecta sp.			6	7	3	3	19
Nepa cinerea L.				1	2		3
Ranatra linearis L.				2			2
Megaloptera:							
Sialis fuliginosa Pictet		1	14		1		16
Trichoptera:							
Trichoptera non det.	64	55	54	73	20		266
Philopotamidae		2					2
Hydropsyche sp.	15		67	52	25	1	160
Coleoptera:							
Dytiscidae	2	3	2	8	7		22
Elmidae		5	15				20
Gyrynidae				10	2		12
Haliplidae		1	2		2		5
Hydrophillidae			1				1

Diptera:							
Ceratopogonidae	4	21	23	11	45	10	114
Chironomidae	125	474	85	23	86	68	861
Empididae	1						1
Limonidae	35	17	14	4	2	3	75
Psychodidae		1					4
Simuliidae	2	7	71	1	4	1	86
Stratiomyidae		1					1
Tabanidae						2	2
Tipulidae					6		6
GASTROPODA:							
Lymneidae non det.	1	2	15	11	11		40
Lymnea stagnalis (L.)				2			2
Planorbidae non det.	1	1	1	1			4
Planorbarius corneus (L.)				2			2
Bithynia tentaculata (L.)				3			3
BIVALVIA:							
Pisidium sp.	1		68		1	1	71
Sphaerium sp.		101		66	8	5	180
Total specimens	1370	1208	1316	645	675	364	5578
taxa	18	24	25	28	29	20	42

*Study sites: 1 – in Jabłonna, 2 – in Czerniejów, 3 – in Mętów, 4 – in Lublin, ul. Głuska, 5 – in Lublin, ul. Mickiewicza, 6 – in Lublin, ul. Fabryczna

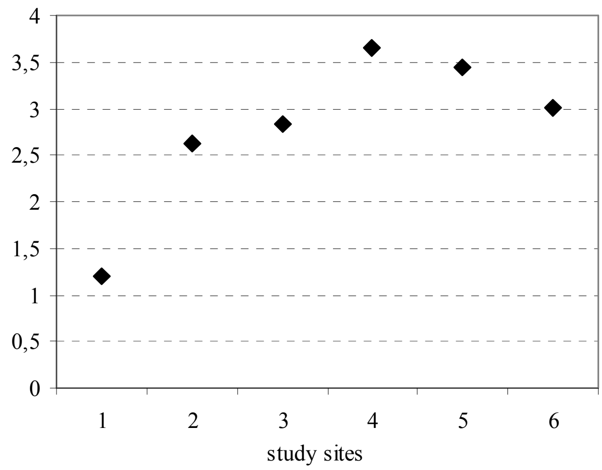

Fig. 1. Shannon-Wiener index at each study site

The dominants at this site were *Gammarus* sp. (28.1%), Hydrachnidia (16.0%), Chironomidae (12.7%), *Asellus aquaticus* (8.1%) and Ceratopogonidae (6.6%). At site 6 (in Lublin, ul. Fabryczna) 20 taxa were noted; most numerous were Oligochaeta (22.8%), Erpobdellidae (22.5%), Chironomidae (18.6%), Hydrachnidia (12.9%) and Corixidae (8.7%).

The biological (taxonomic) diversity index ranged from 1.20 to 3.66 (Fig. 1). The highest biological diversity was noted at the urban study sites, with abundant aquatic vegetation (site 4, H = 3.66 and site 5, H = 3.45), while the lowest was found at the sites with a sandy bottom (site 1, H = 1.20 and site 2, H = 2.62) – Fig. 1.

DISCUSSION

The 5,578 macroinvertebrate specimens, belonging to 42 taxa, which were collected in the Czerniejówka River during one study season, indicate the quantitative and qualitative richness of the bottom and phytophilous fauna inhabiting the river. The number of taxa would of course be far greater if each taxon were determined to species.

The number of specimens and taxa caught and the domination structure varied among the various study sites. It may seem surprising that at the sites outside the city, where the river retained its natural character and human impact was negligible (sites 1–3), fewer taxa were collected (18 to 25) than at the urban sites, where there was far greater human impact (sites 4–6, from 20 to 29 taxa). This was due to the habitat conditions prevailing at different sites. For example, at site 1 the small number of taxa was the result of low habitat diversity; the bottom was sandy and without aquatic vegetation, while the microhabitats with muddy bottoms and slow water flow were not well-developed. The biocoenosis of this stretch of the river was dominated by one taxon, *Gammarus* sp., which constituted as much as 79.9% of the fauna collected at the site. The rapid water flow here (0.45 m/s) was a factor favourable to the development of such rheophilic organisms as gammarids. Gammarids were also numerous at the other sites (except site 6), but it may be noted that the proportion of such taxa as Oligochaeta, Erpobdellidae, *Asellus aquaticus*, Corixidae, *Sphaerium* sp. *Pisidium* sp. and Corixidae increased with the course of the river (Tab. 1). These taxa are typical of littoral zones with slower water flow [Logan and Brooker 1983, Piechocki and Dyduch-Falinowska 1993, Czerniawska-Kusza 2001], and such habitats were well-developed in the lower stretch of the river. The increasing quantitative share of the taxa mentioned was also influenced by abiotic factors (a greater proportion of muddy sediment and slower water flow than at other sites) and biotic factors (abundant aquatic vegetation).

The values for the physical and chemical indices of the water (temperature, pH, electrolytic conductivity, dissolved oxygen and oxygen saturation) did not change much along the course of the river, but the higher electrolytic conductivity at the urban sites (sites 4–6, on average 620 to 694 µS/cm) and the somewhat less favourable oxygen conditions than at the sites outside of the city (on average 8.44 to 8.92 mgO_2/l) may indicate worsening water quality. The changes in the physical and chemical indices of the water were small, but changes in the composition of the fauna at different sites are a far greater indicator of increasing water pollution. In the upper course of the river gammarids, which are typical of clean water [Maltby *et al*., 2009, Kunz *et al*. 2010], were highly abundant. At the first two urban sites (sites 4 and 5) *Gammarus* sp. is still the most numerous taxon, but its frequency is not as high as at sites 1–3 (Tab. 1). The increasing pollution of the river at the sites within Lublin may be indicated by the gradual appearance of taxa associated with polluted water. At site 5, for example, along with the still numerous gammarids, a fairly numerous population of *Asellus aquaticus* was noted (Tab. 1). According to Whitehurst [1991], a decreasing quantitative share of *Gammarus* sp. accompanied by an increasing share of *Asellus* sp. indicates increasing organic pollution of the water. The increasing water pollution is most clearly seen in the taxonomic composition and dominance structure of the fauna at site 6 – the estuarine stretch of the river located in the city centre. Oligochaeta and Chironomidae dominated at this site, which is evidence of water pollution [Hawkes 1979, Leynen *et al*. 1999, Czarniawska-Kusza 2001, Martins *et al*. 2008]. The estuarine stretch of the river was also the site where the most numerous population of Erpobdellidae was noted (82 individuals, 45.8% of the fauna at this site). These leeches tolerate water polluted with excess organic matter [Murphy and Learner 1982]. Lower frequency of taxa sensitive to water pollution was also observed at this site. Only 47 Hydrachnidia specimens were collected here – far less than at the other sites (Tab. 1). Water mites are very sensitive to water pollution [Kowalik 1981, Kowalik and Biesiadka 1981, Gerecke and Schwoerbel 1991], hence their infrequent occurrence, compared with the other sites, confirms that the fauna in the estuarine stretch of the river has been degraded.

In spite of the natural character of the upper course of the river and the negligible human impact there, the values for the taxonomic diversity index at sites 1–3 were lower (H = from 1.2 to 2.8) than at the urban sites (H = from 3.01 to 3.66), where the river was subject to greater or lesser human impact. The lowest value for the Shannon-Wiener index was at site 1 (H = 1.2). This resulted from the small number of taxa and the clear dominance of one of them – *Gammarus* sp. constituted as much as 79.9% of the fauna collected here. The habitat conditions prevailing at this site (fast current, lack of aquatic vegetation and of areas with muddy bottoms and very slow current), which are preferred by rheophiles such as gammarids, can at the same time be considered natural environmental stress for organisms that prefer slower water flow and life in the muddy sediments of the river's lentic zone. According to Odum [1982], low biodiversity is characteristic of unstable biocoenoses subjected to seasonal or periodic disturbances caused by man or nature. A biocoenosis reacts to environmental stress with a decrease in the number of species which are poorly represented, accompanied by an increase in the significance, i.e. dominance, of species with a high tolerance for stress [Odum 1982]. In this case the reaction of the biocoenosis to environmental conditions (fast water flow) was a very large quantitative share of gammarids accompanied by infrequent occurrence of organisms that prefer slower water flow (Tab. 1). At the urban sites (sites 4–6) more taxa were noted and the dominance distribution was more uniform. These two factors contributed to higher values for the Shannon-Wiener index.

CONCLUSIONS

1. The taxonomic diversity of the macroinvertebrate communities of the river Czerniejówka was influenced by biotic factors – the most taxa were collected at sites with abundant aquatic vegetation.

2. Abiotic factors (water current, type of bottom sediments) affected the frequency of occurrence of the fauna; the most specimens from taxa that prefer a given factor were observed at sites where that factor was dominant.

3. The physical and chemical properties of the water did not vary significantly on the stretch of river studied. Only the somewhat higher electrolytic conductivity and the somewhat lower dissolved oxygen content at the sites within Lublin may indicate worsening water quality.

4. A much more precise indicator of the degradation of the river was the analysis of macroinvertebrate populations. At the urban sites (4–6) a gradual increase in the proportion of taxa tolerant of water pollution was observed; however, marked degradation of fauna was noted only in the estuarine stretch of the river, in the centre of Lublin. The effect of this degradation was the small number of taxa and species noted and the dominant share of taxa characteristic of polluted water bodies.

5. Human impact – straightening of the river bed, dikes, changes in the structure of the banks, concrete on the bottom – did not affect the fauna. At the sites where such human impact was present, many taxa were collected and biological diversity was even greater than at the sites where the river course was natural.

REFERENCES

Cieślak J., 2006. Invertebrate fauna of the river Minina in Kozłowiecki Landscape Park (in Polish). Uniwersytet Przyrodniczy w Lublinie, (typescript), pp. 56.

Czerniawska-Kusza I., 2001. Changes in the bottom fauna community of the lower course of Nysa Kłodzka induced by abiotic and anthropogenic factors (in Polish). Opolskie Towarzystwo Przyjaciół Nauk, Zeszyty Przyrodnicze 35, 72–84.

Gerecke R., Schwoerbel J., 1991. Water quality and water mites (Acari, Actinedida) in the upper Danube region, in: Dusbabek F., Bukwa V. (eds) Modern Acarology 1. Academia Prague, 483–491.

Gorzel M., 2008. Benthic macroinvertebrates as an indicator of the ecological state of tributaries of the river Bystrzyca Lubelska with varying degrees of anthropogenic transformation (doctoral thesis) (in Polish). Uniwersytet Warmińsko-Mazurski w Olsztynie (typescript), pp. 161.

Hawkes H.A., 1979. Invertebrates as indicators of river quality, in: James A., Evison L. (eds) Biological indicators of water quality. J. Willey & Sons, Chichester, 2–45.

Kowalik W., 1981. Water mites (Hydracarina) in the rivers of the Wieprz basin (in Polish). Ann. UMCS, sec. C, 25, 327–351.

Kowalik W., Biesiadka E., 1981. Occurrence of water mites in the River Wieprz polluted with domestic-industry sewage. Acta Hydrobiol. 23, 331–348.

Kunz. P.Y., Kienle C., Gerhardt A., 2010. *Gammarus* spp. in aquatic ecotoxicology and water quality assessment: toward integrated multilevel tests. Rev. Environ. Contam. Toxicol. 205, 76.

Leynen M., Van den Berckt T., Aerts J.M., Castelein B., Berckmans D., Ollevier F., 1999. The use of Tubificidae in a biological early warning system. Environ. Poll., 105, 1, 151–154.

Logan P., Brooker M.P., 1983. The macroinvertebrate faunas of riffles and pools. Wat. Res. 17, 263–270.

Maltby L., Clayton S.A., Wood R.M., McLoughlin N., 2009. Evaluation of the *Gammarus pulex* in situ feeding assay as a biomonitor of water quality: Robustness, responsiveness, and relevance. Environ. Toxicol. Chem., 21, 2, 361–368.

Martins R.T., Stephan N.N.C., Alves R.G., 2008. Tubificidae (Annelida: Oligochaeta) as an indicator of water quality in an urban stream in Southeast Brazil. Acta Limnol. Bras., 20 3, 221–226.

Murphy P.M., Learner M.A., 1982. The life history and production of the leech *Erpobdella octoculata* (Hirudinea: Erpobdellidae) in the River Ely, South Wales. J. Anim. Ecol., 51, 57–67.

Odum E.P., 1982. Fundamentals of ecology (in Polish). PWRiL, Warszawa, pp. 661.

Piechocki A., Dyduch-Falinowska A., 1993. Molluscs (Mollusca), Bivalves (Bivalvia). Freshwater fauna of Poland (in Polish). Wydawnictwo Naukowe PWN, pp. 202.

Stryjecki R., 1992. Bottom fauna of the river Bystra (in Polish). Uniwersytet Przyrodniczy w Lublinie (typescript), pp. 45.

Whitehurst I.T., 1991. The effects of sampling techniques on the *Gammarus: Asellus* ratio. Water Res. 25, 6, 745–748.

Więch K., 2008. Heteroptera aquatica communities and other invertebrate fauna of the Czechówka and Czerniejówka rivers, with an assessment of water quality (in Polish). Uniwersytet Marii-Curie Skłodowskiej (typescript), pp. 55.

MAKROFAUNA DENNA I FITOFILNA RZEKI CZERNIEJÓWKI NA TLE CZYNNIKÓW BIOTYCZNYCH, ABIOTYCZNYCH ORAZ ODDZIAŁYWANIA ANTROPOGENICZNEGO

Streszczenie. Badano makrofaunę denną i fitofilną rzeki Czerniejówki w dwóch typach krajobrazu – wiejskim i miejskim. W obszarze wiejskim rzeka miała naturalny charakter, zaś w obszarze miejskim była poddana silnej antropopresji (wyprostowanie koryta, zmiana struktury brzegów, utwardzenie dna, zanieczyszczenie wody). Złowiono 5578 osobników makrobezkręgowców należących do 42 taksonów o różnej randze systematycznej. W całości zebranego materiału dominowały: *Gammarus* sp. (41,2%), larwy Chironomidae (15,4%) oraz Hydrachnidia (10,7%). Wskaźnik różnorodności biologicznej wahał się w granicach 1,20 do 3,66. Na skład taksonomiczny oraz liczebność fauny wpływały głównie czynniki biotyczne (np. stopień rozwinięcia roślinności wodnej) oraz abiotyczne (np. prąd wody, charakter osadów dennych). Natomiast charakter krajobrazu (wiejski i miejski), oddziaływanie antropogeniczne, a także właściwości fizyczno-chemiczne wody nie miały większego wpływu na faunę rzeki.

Słowa kluczowe: makrobezkręgowce, czynniki biotyczne, czynniki abiotyczne, oddziaływanie antropogeniczne, różnorodność biologiczna